

**LOWER POWER AND REDUCED DEVICE SPLIT  
LOCAL AND CONTINUOUS BITLINE  
FOR DOMINO READ SRAMS**

CROSS REFERENCE TO RELATED APPLICATION

The present application is related to U.S. Patent Application entitled "SPLIT LOCAL AND CONTINUOUS BITLINE FOR FAST DOMINO READ SRAM," serial no. \_\_\_\_\_ (attorney docket no. ROC820010594) filed \_\_\_\_\_, and to U.S. Patent Application entitled "SPLIT LOCAL AND CONTINUOUS BITLINE REQUIRING FEWER WIRES", serial no. 10/289,804, filed July 7, 2002.

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TECHNICAL FIELD

The invention relates generally to static random access memory (SRAM) cells and, more particularly, to using a continuous bitline in conjunction with an SRAM cell.

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BACKGROUND

SRAMs (static random access memories) are memory elements that store data in the form of complementary low voltage and high voltage at opposite sides of the SRAM. An SRAM, unlike dynamic random access memory (DRAM), maintains the memory value all of the time that power is applied to the circuit. This is unlike the DRAM, which is periodically refreshed with the value to be saved. If the "true" node is read as a high voltage, the value of the SRAM is one. If the true polarity node is read as a low voltage, the value of the SRAM is zero.

Within some SRAMs, there are individualized write true (WriteT) lines and write complementary (WriteC) lines that are used to write complementary values to the complementary polarity nodes inside. However, it was discovered that the

separate WriteC bitline to each individual SRAM cell could be replaced by a continuous bit-line complementary (BLC) to all of the SRAMs cells along the same bitline. A bitline can generally be defined as a connection to a plurality of 5 SRAM cells at a transfer gate.

However, as processing speeds increase and devices within integrated circuits become ever smaller, the complexity of the SRAM cell, and power consumption of the SRAM are of ever-increasing concern. Even though use of the 10 continuous BLC line within an SRAM cell has reduced some of the complexity of the local evaluator, these issues are still of concern to chip designers.

Therefore, there is a need for an SRAM design that overcomes at least some of the issues associated with 15 conventional SRAM design.

#### SUMMARY OF THE INVENTION

The present invention provides for reading indicia from an SRAM cell. A low value is generated on a write true 20 line. A high value is generated on a continuous bit line. The true node of the SRAM cell is evaluated.

#### BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present 25 invention, and the advantages thereof, reference is now made to the following Detailed Description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 schematically depicts a conventional SRAM design; and  
30 FIGURE 2 illustrates an SRAM cell with a continuous bit-line and a simplified configuration of precharge circuits.

DETAILED DESCRIPTION

In the following discussion, numerous specific details are set forth to provide a thorough understanding of the present invention. However, those skilled in the art will 5 appreciate that the present invention may be practiced without such specific details. In other instances, well-known elements have been illustrated in schematic or block diagram form in order not to obscure the present invention in unnecessary detail. Additionally, for the most part, 10 details concerning network communications, electro-magnetic signaling techniques, and the like, have been omitted inasmuch as such details are not considered necessary to obtain a complete understanding of the present invention, and are considered to be within the understanding of persons 15 of ordinary skill in the relevant art.

It is further noted that, unless indicated otherwise, all functions described herein may be performed in either hardware or software, or some combination thereof. In a preferred embodiment, however, the functions are performed 20 by a processor, such as a computer or an electronic data processor, in accordance with code, such as computer program code, software, and/or integrated circuits that are coded to perform such functions, unless indicated otherwise.

Turning to FIGURE 1, disclosed is a prior art SRAM 100 having an SRAM cell 110. The SRAM 100 does not have a continuous BLC. The SRAM cell 100 has a true node 112 and a complementary node 114 coupled to a local true bitline (LBLT) 106 and a local complementary bitline (LBLC) 107, respectively. The SRAM cell 110 is also coupled to a 25 wordline 105 through the gate of a first and second transistor 111, 113.

A precharge line 115 is coupled to a first precharge circuit 131 and a second precharge circuit 133 through their

respective gates. In FIGURE 1, the first and second precharge circuits 131, 133 use positive field effect transistors (PFETs). As is understood by those of skill in the art, a PFET functions as a short when a low value is applied to its gate, and an open when a high voltage is applied to its gate.

The LBLT 106 is coupled to an LBLT node 118, and the LBLC 107 is coupled to a LBLC node 119. The LBLT node 118 is coupled to the drain of the first precharge circuit 131. 10 The LBLC node 119 is coupled to the drain of the second precharge circuit 133. The source of the precharge circuits 131, 133 are both coupled to a high voltage source 157. The LBLT node 118 is further coupled to a local evaluator 120, which is coupled to a second stage evaluator 122.

15 Coupled to the LBLT and LBLC nodes 118, 119 are the drains for a first write circuit 136 and a second write circuit 138, respectively. The sources of the write circuits 136, 138 are coupled to ground. In FIGURE 1, the first and second write circuits 136, 138 have negative field 20 effect transistors (NFETs). As is understood by those of skill in the art, a NFET functions as an open when a low value is applied to its gate, and a short when a high voltage is applied to its gate.

The gates of the write circuits 136, 138 are coupled to 25 a WriteT line 141 and a WriteC line 143, respectively. The WriteT line 141 and WriteC line 143 are coupled to the respective outputs of a write predriver circuit 150. The write predriver circuit 150 has a data in line 153 and a write enable line 156.

30 To either read from the SRAM cell 110 or write to the SRAM cell 110, the wordline 105 is asserted from a default logical low state to a logical high state. Furthermore, when reading from the true node 112 of the SRAM cell 110 at

the coupled local evaluator 120, the value on the WriteT and WriteC 141, 143 lines are zero. Because the write-lines 141, 143 values are zero, the write circuit 136, 138 are turned off during a read. Therefore, there is an open 5 circuit between the LBL nodes 118, 119 and ground.

Furthermore, when reading from the LBLT line 106 through the local evaluator 120, the precharge line input 115 transitions from a zero to a one, which turns off the precharge circuit 131, thereby opening the connection 10 between the LBLT node 118 and high voltage source (VBB) 157. However, the write circuit 136 is still open, as WriteT 141 is inputting a zero value into the write circuit 136 NFET. Therefore, the voltage on the LBLT node 118 is floating. In 15 floating, an entity, such as the LBLT node 118, is not being driven by an applied voltage. For example, when the WriteT line 141 is on, the LBLT node 118 is driven to ground. However, if the LBLT line 141 is off, the LBLT node 118 is floating, if the precharge circuit 131 is also an open. In 20 FIGURE 1, whether the true node 112 is at ground or high is read by the local evaluator 120.

In FIGURE 1, during a read, if the true node 112 of the SRAM cell 110 stored voltage value is zero, the floating voltage of the LBLT node 118 discharges to ground into the SRAM cell 110. The resulting ground LBLT node 118 voltage is 25 read by the local evaluator 120. Alternatively, if the true node 112 of the SRAM cell 110 stored voltage value is high, the LBLT node voltage 118 value stays substantially the same as a high voltage. In any event, the LBLT node 118 voltage 30 value is proportional to the voltage of the T node 112 of the SRAM cell 110.

In FIGURE 1, during a read, both the WriteT 141 and the WriteC 143 lines are zero, which means that the LBLC node 119 voltage value is floating at the precharge value high

voltage value. As complementary voltages are not being applied to both the T and C nodes 112, 114 of the SRAM cell at the same time, the values stored in the SRAM cell 110 do not change as a function of being read.

5       The value of WriteEnb on line 156 is a "one" if not writing to the SRAM cell 110, and a value of a "zero" if a value is being written to the SRAM cell 110. The value of DataIn on line 153 is a "zero" or a "one," as appropriate. If writing, the WriteEnb 156 value is zero. If writing, the wordline 105 value and the precharge 115 value are also raised to a one. Before being driven by the WriteT and WriteC values, a floating voltage is created at both the LBLT 118 and the LBLC 119 nodes.

10      If writing, the WriteEnb 156 value is zero, which means that the WriteT 141 and the writeC 143 values will complement one another. Therefore, then the WriteC 143 and WriteT 141 values come to drive the voltages at the LBLT 118 and the LBLC 119 nodes. When either the WriteT 141 or WriteC 143 value is low, the corresponding NFET write circuit 133, 138 stays open, and the corresponding LBL node 118, 119 starts off as a floating high voltage. However, the high floating value of the LBL node voltage discharges to ground when the corresponding NFET write circuit turns on for the non-zero WriteT 141 or WriteC 143 values.

15      This means that both the LBLT node 118 and the LBLC node 119 become driven complements of one another, and these complementary voltages are then stored in the T and C nodes 112, 114 of the SRAM cell 110, as one value is floating high, but the other one is driven to ground by either write circuit 133, 138 being turned on (that is, going to ground). This means that the LBLT 106 values and the LBLC 106 values can be written to the SRAM cell 110, as both the writeT 141 and WriteC 143 lines are complementary, which means that

either the write circuit 136 or the write circuit 138 drives the true node 112 or complement node 114 to ground.

Turning now to FIGURE 2, disclosed is an SRAM cell system 200 with a continuous bit\_line 260 and a simplified configuration of precharge circuits. Generally, SRAM cell 200 allows for the elimination of one of the precharge circuits of FIGURE 1. In the system 200, a continuous BLC 260 is coupled to a plurality of SRAM cells 210 (not shown). When attempting a write, all coupled SRAM cells 210 receive the same continuous BLC 260 value. However, through the use of a selected wordline 205, only the selected SRAM cell 210 is written to.

In the SRAM cell 200, the continuous BLC 260 does not have a precharge circuit. In one aspect, a portion of the circuitry and functionality of a precharge circuit 133 can be found in predriver circuit 290 for use with the continuous BLC 260. However, those of skill in the art understand that other logic circuits that have the same functionality as the write predriver circuit 290 can be substituted for the write predriver circuit 290.

In the system 200, a precharge 215 is coupled to a portion of a second precharge circuit 272. The portion of the second precharge circuit 272 can be a PFET. The drain of the second PFET 272 is coupled to the LBLT node 270, and the source of the second PFET 272 is coupled to the drain of the first precharge circuit 271. The WriteT 241 is coupled to the gate of the first precharge circuit 271. The source of the precharge circuit 271 is coupled to a system high voltage (VBB) 257.

30 In the system 200, whenever a read is occurring, the write\_Enb 256 value is one. This is inverted to a zero by a predriver inverter 257. The zero value is input into a predriver NAND 259. Therefore, the value output of the NAND

259, and hence the write predriver circuit 290, is a high voltage, and therefore the continuous BLC 260 is high during a read.

During a read, the WriteT 241 value is low. As the WriteEnb 256 input is a high, this high value is input into the predriver NOR 258, which is output as a low. Therefore, the WriteT 241 output of the write predriver circuit 290 is a low during a read.

10 During the read of the SRAM 210, the true node 212 of the SRAM cell 210 is read. During the read function, there is a low signal on the WriteT 241 (as a function of the WriteEnb signal 256), so the LBLT node 270 voltage is not connected to ground, as the NFET write circuit 280 is open. Furthermore, the precharge 215 value is transitioned to one, 15 which turns off (opens) the second precharge PFET 272, thereby creating a floating LBLT 270 node.

20 During a read, the SRAM true node 212, if it has stored within it a low value, will function as a sink for the floating node LBLT 270 value, thereby taking the value of the floating LBLT node 270 to zero, and read by an evaluator 220. In a further embodiment, a NAND gate is used within 220. In a further embodiment, a NAND gate is used within the local evaluator 220, instead of an inverter.

25 The SRAM true node 212, if it has stored within it a high voltage value, drives a high voltage on the LBLT node 270, which is also read by the evaluator 220. In the system 200, the values in the SRAM stored within the true node 212 and the complementary node 214 of the SRAM cell 210 are not changed during a read, because complementary voltages are not being driven on the true node 212 and complementary node 30 214 simultaneously when wordline 205 is on.

In the system 200, during a read, both the LBLT node 270 and the continuous BLC 260 start out coupled to a high

voltage. During a read, the SRAM cell 210 true node 212 and complementary node 214 values do not change.

During the write function, the wordline 205 is turned on, but the precharge 215 is kept at a zero, unlike the 5 transition of the precharge 115 in FIGURE 1. During a write, therefore, the second PFET 272 functions as a short between the drain of the first PFET 271 and the write circuit 280. The voltage at the LBLT node 270 is therefore driven either to high source voltage 257 or to ground, as 10 either the first PFET 271 or the write circuit 280 NFET is a short, as a function of the WriteT 241 value. As is also understood by those of skill in the art, although NFETs and PFETs are disclosed in FIGURE 2, other FETs are within the scope of the present invention.

15 The WriteT 241 value is used to input a high charge or a low charge to the nodes 212 and 214 of the SRAM cell 200, depending upon the polarity of the WriteT function 241, which is in turn a function of the Data In. If the WriteT 241 value is high, the NFET write circuit 280 is turned on. 20 Furthermore, the first PFET 271 is turned off. The LBLT node 270 is therefore drained to zero voltage value, which is written into the true node 212 of the SRAM cell 210. This value is written to the true node 212 of the SRAM cell 210 due to the driving of the high voltage through the 25 continuous BLC 260 and the driving of a grounded voltage at the LBLT 270, as opposed to applying a high voltage through the continuous BLC 260, but floating a voltage at LBLT node 270 during a read.

However, if the WriteT 241 value is zero, the first 30 PFET 271 coupled to the WriteT 241 is turned on (shorts), as zero input turns on the first PFET 271. The NFET write circuit 280, however, is off, and the LBLT node 270 voltage value is driven to the source voltage value 257.

Furthermore, the complementary value of the WriteT 241 is found in the continuous BLC 260. This also occurs during the writing to the SRAM 210. For instance, if the WriteT 241 value is one in a write, the continuous BLC 260 value is zero. Because two complementary voltages are driven into the SRAM T and C nodes 212, 214, the SRAM 210 accepts these complementary voltages and stores them within the SRAM 210.

In the system 200, during a write, the precharge does not transition voltage states from a zero to a one. This can lead to power savings, as power consumption and heat production can be proportional to the frequency of voltage switching. Furthermore, in the system 100, the wordline 105 and the precharge 115 during the write signal all transitioned at approximately the same time, which can create timing difficulties to implement. If the transitions of the precharge 115 and the wordline 105 did not occur at the proper time in the system 100, a short could occur between the high voltage 157 and ground. In the system 200, however, during a write, the PFET 271 and 272 and the NFET 280 are configured so that there will not be a short between the voltage high 257 and the ground during the write at the same time.

It is understood that the present invention can take many forms and embodiments. Accordingly, several variations may be made in the foregoing without departing from the spirit or the scope of the invention. The capabilities outlined herein allow for the possibility of a variety of programming models. This disclosure should not be read as preferring any particular programming model, but is instead directed to the underlying mechanisms on which these programming models can be built.

Having thus described the present invention by reference to certain of its preferred embodiments, it is

noted that the embodiments disclosed are illustrative rather than limiting in nature and that a wide range of variations, modifications, changes, and substitutions are contemplated in the foregoing disclosure and, in some instances, some features of the present invention may be employed without a corresponding use of the other features. Many such variations and modifications may be considered desirable by those skilled in the art based upon a review of the foregoing description of preferred embodiments.

10 Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.